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USING CLOUD COMPUTING FOR STEM EDUCATION IN GENERAL SCHOOL

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The article is devoted to the problems of using cloud services for the STEM-education support in a general school. There has been studied the foreign experience of solving the main issues on the implementation of STEM-oriented approach at all educational levels with the help of information and communication technologies. The purpose of the article is to analyze the foreign experience of using cloud computing services for the STEM-education support at a general school and highlight the main problems which may arise during this process. It is concluded that STEM-education is one of the most important areas of education system development and education reforming, which is explained by the significant demand of the world labor market for specialists in the STEM industries. The use of information and communication technologies, in particular cloud services, ensures effective implementation of the STEM-oriented approach in general educational institutions at all levels of education.

Key words: *information and communication technologies, teacher's information and communication competence, cloud computing services, general school, STEM-oriented approach, STEM-education.*

Introduction

The rapid development of the information society contributes significantly to the scientific research and the emergence of new fields of knowledge and technologies, such as information and communication technologies (ICTs), nanotechnologies, biotechnologies, etc. This leads to changes in the priorities in the field of education [1].

The educational process of the general educational institution is focused on the orientation of teachers towards a competent approach, the development of students' sense of initiative and entrepreneurship, creative thinking, the ability to transform ideas into life through creativity, innovation, etc.

One of the main trends of education modernization is the STEM-education, which involves the integration between the the natural sciences, the technological sciences, engineering, and mathematics in the learning process of educational institutions, in particular, general educational institutions.

Although there is a problem with the selection of the necessary forms, methods and means for the effective organization of such education. One of the global approaches to ensure this process is the use of ICTs, in particular cloud services, reflected in such international instruments of strategic importance as the European Union's International Project “Assessment and Learning in the 21st Century Skills” (ATC21S) [2], UNESCO ICT Competency Framework for Teachers [3], “DigComp 2.0: The Digital Competence Framework for Citizens” [4], “DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use” [5], etc.

This research is aimed at answering the following questions:

- What problems can arise when using cloud technologies for STEM-education?
- Which are cloud services for the STEM-education?
- How to solve the problem of using cloud technologies for the STEM-education support in a general school?

The problems of STEM-education implementation in a general school are being considered by scientists Barna, O. and Balyk, N. (2017), Маπтй Debry and Dr. Agueda Gras-Velazquez (2016), Vimala Judy Kamalodeen etc. (2017), Heidi Sublette (2013), Nikirk, M. (2012), etc

The use of ICT, in particular cloud services, for improving the organization of the learning process in a general school has been analyzed in the research works of such scientists as Bykov, V. (2008), Carretero, S. (2017), Vuorikari, R. (2016), Koutsopoulos, K. (2015), etc.

Researchers Barna, O., Balyk, N. suggest that “STEM-education” is a pedagogical approach, which involves studying science and technology through the use of technical creativity and engineering, based on mathematical calculations and modeling, as well as integrated use of various learning tools and tools of other sciences [6].

Nikirk, M. (2012) [7] defines the STEM-education as a transdisciplinary teaching approach that enables students to use the project method to solve real life problems independently and do training tasks set by a teacher, in which the teacher plays the role of a facilitator. Researcher recommends such strategies for the effective implementation of the STEM-oriented approach in a general school:

- demonstrating graphs at the beginning of setting tasks, etc., since visualization facilitates faster perception of the material than just reading a text;
- beginning with an explanation of the purpose, which should be objective;
- after explaining the goal it is necessary to provide students with accurate and abstract concepts to be realized using examples from real life, the students should understand the connection with abstract concepts;
- using ICTs for interactive educational process, namely, for searching and presenting educational resources; creating and using virtual laboratories, electronic educational games, software, blogs, etc.;
- teaching the business conduct and etiquette that meets the needs of business and entrepreneurship; presenting data with charts and graphs by using graphical editors and presentations;

- focusing not on the teacher-centered approach, but on the learner-centered approach;
- focusing not on the group-work, but on the team-work;
- promoting the development of an educational environment, in which the core values are students' creative and independent thinking;
- engaging students in the interactive learning activity; teaching them to be efficient at evaluating and using technologies, including ICTs, for learning and self-education;
- using the "peer-to-peer" method, that is to engage students as teachers, project leaders, problem solvers, which should build their leadership skills.

The abovementioned recommendations highlights the ICTs' special role, in particular, cloud services, for the STEM-education support in a general school.

There is highly important to create ICTs' centers support for the STEM-education, STEM Alliance or Association, etc. For examples: the All-Ukrainian Scientific and Methodological Virtual STEM Center of the Minor Academy of Sciences of Ukraine (available at: http://stemua.science/); European Union STEM Alliance inGenious Education and industry (available at: http://www.stemalliance.eu); American National School Boards Association (available at: https://www.nsba.org), etc.

The STEM-educational environment of the All-Ukrainian Scientific and Methodological Virtual STEM Center consists of three components:

- Information and technological component (educational programs, methodical materials, virtual laboratories);
- Dimensional and material component (equipment and software for leading local and foreign producers);
- Social and personal component (students of general schools and out-of-school educational institutions, students of higher educational institutions, scientists and researchers, etc.).

The European Union STEM Alliance has a similar structure to the All-Ukrainian Scientific and Methodological Virtual STEM Center.

Maite Debry and Dr. Agueda Gras-Velazquez, etc. [8] consider that STEM Alliance should pay particular attention to cloud services for the STEM-education support. They note that using ICTs will encourage students' active, interactive and collaborative learning; will increase their interest and motivation to study STEM disciplines. The scientists consider the cloud services will ensure interactive and collaborative learning activities of students and teachers: Microsoft Office 365, Google Docs, Microsoft OneDrive, Padlet, Skype, etc.

Although they denote such problems [8] as: creating formal and informal on-line courses in the STEM fields and engaging students, teachers and specialists in this activity; continuing development of teachers' information and communication competence (digital competence) for them to improve the STEM learning environment by using ICTs; selecting necessary ICTs for organizing the learning process, etc. They propose to conduct training courses for teachers. Such courses should be aimed at teaching listeners to select and use ICTs, in particular cloud services, in accordance with the forms, methods and content of the subject at

school. The scientists point out the following popular courses in EU countries: “TeachScape” and Knowledge Delivery System (KDS); Massive open online courses (MOOC), such as, for example, European Schoolnet Academy (available at: http://www.europeanschoolnetacademy.eu), Microsoft Imagine Academy (available at: https://member.imagineacademy.microsoft.com (English); http://kubg.edu.ua/struktura/pidrozdili/ndl-informatizatsijiosviti/proekty/microsoft-imagine-academy.html (Ukrainian), etc.

The scientists especially note the important role of MOOC in the development of teachers’ digital competence, which is necessary in their professional activity according to global priorities of education. For example, there are European Schoolnet Academy courses “Boosting a Sense of Initiative and Entrepreneurship in Your Students”; “Opening minds to STEM careers”, “Opening Schools to STEM Careers”, etc.

The scientists explain the effectiveness of such courses because of the fact that they involve a large number of teachers from different countries, who can exchange positive experience on the use of ICTs, find out common educational problems to be discussed and solved, etc. [9]. The teachers are suggested to investigate different ideas about the forms, methods and means of the STEM-oriented approach support.

These courses are the result of international projects created for solving current educational problems and meeting the information society needs. For example, the “Opening Schools to STEM Careers” course is the result of three projects: SYSTEMIC (available at: http://www.ngofund.org.pl/systemic-projects/), which was the joint initiative between the Ministries of Education in Europe and employers, who have a common goal of encouraging young people in STEM careers; Scientix (available at: http://www.scientix.eu), which provided a community of teachers and specialists for the support and development of the STEM education in Europe and cooperation of teachers, researchers, political and other professionals; STEM Alliance (available at: http://www.stemalliance.eu/), which was aimed at identifying shortcomings in the development of mathematics and natural sciences in Europe and providing suggestions for its improvement [10].

In addition to the abovementioned, the scientists pay attention to the potential of cloud services for the creation and use of games in order to motivate students’ learning and improve the STEM-education, using such cloud services as Scratch (available at: http://scratch.mit.edu), Microsoft Kodu (available at: www.kodugamelab.com), Minecraft (available at: https://minecraft.net/en-us/download), World of Warcraft (available at: https://worldofwarcraft.com), etc. [3, 8, 10]. In order to explain the role of these services in the learning process at a general school and for training teachers to use them in their professional activities, there were developed three rounds of massive open online courses: “Games in Schools first round”, “Games in Schools 2nd round”, “Games in Schools 3rd round”in the European Schoolnet Academy.

The main issues that are considered in these courses are as following: “why use computer games at schools?”; “how use cloud services to increase students’ motivation to study and improve the educational process of different disciplines?”

etc.

So, the “Opening Schools to STEM Careers” course offers a range of computer games and cloud services. The course tutors divide them conditionally into the following groups:

- which do not necessarily have an educational purpose, but can be used for thematic training on, for example, programming, gravity, planet, construction and many others;

- which are pedagogically- orientated and designed to help students study in various fields of science.

At the same time, researchers pay particular attention to the Scratch cloud service, which was created in the Massachusetts Institute of Technology Media Laboratory [10]. The work on this project was focused on helping students develop critical, creative thinking, individual and cooperative learning and teaching work in the classroom, encouraging joint educational activities, and the interdisciplinary approach to the learning process with ICT, and others [10]. The Scratch service can be used for the following purposes: teaching students programming, algebra and geometry problems solving, presentations of the educational projects of different educational disciplines, creativity at presenting materials as a result of scientific research, and others.

The abovementioned problems on using cloud services for the STEM-education support contributed to implementing a number of international projects, for example: The Global Learning and Observations to Benefit the Environment (GLOBE, available at: https://www.globe.gov/), Group-Based Cloud Computing for STEM Education Project (GbCC, available at: https://www.gbccstem.com/), School on the Cloud (available at: http://www.schoolonthecloud.net/), etc.

The GLOBE (started in 1995) is an international scientific and educational program that provides students, teachers and scientists all over the world with the opportunity to participate in data collection and studying mathematics and natural sciences, to promote better understanding the Earth system and the global environment. This cloud project (created in 2012) is the infrastructure, which provides the data exchange between its registered participants, joint work on scientific research by educational institutions of different countries, etc.

The GLOBE Program Operational Structure consists of three levels (Fig. 1): Primary Activities, Support Infrastructure and Underpinning Operations).

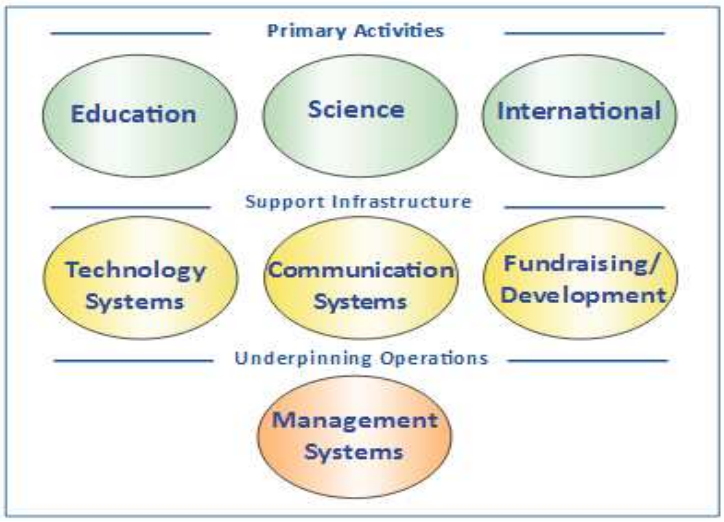

Fig.1. The GLOBE Program Operational Structure [11]

Primary Activities include such components:

- Education: development and support of events for teachers and trainers in the field of environmental sciences; communication with teachers, exchange of best practices and provision with learning tools; facilitating the students' learning, students' cooperation with the GLOBE community;
- Science: engaging scientists, which are STEM specialists, to the GLOBE network community; coordination of scientific activity and educational relations; organization of project participants' communication with scientists, sharing best practices and providing feedback to schools;
- International relations: engaging and supporting international partners, sharing best practices between international coordinators and partners, creating conditions for teachers' training, which are involved in the GLOBE project.

Support Infrastructure includes such components:

- Technology Systems: Websites development for GLOBE, providing cloud-based training support, data visualization of pupils and students involved in the GLOBE project;
- Communication Systems: providing constant support for communication between schools, registered in the project, and scientists and partners; regular news reports on the project, etc.;
- Fundraising/Development: finding financial resources for relevant projects within the GLOBE and a strategic plan for infrastructure support.

Underpinning Operations cover management systems. Their task is to maximize the effectiveness of all activities in the GLOBE, providing adequate monitoring, review, evaluation of services and ensuring their constant improvement.

GbCC project is aimed at implementing a research approach using cloud services to create and study technologies, and materials that support STEM-education and training. The GbCC sites have such goals:

- Distributing approaches to the teachers training and certification for the STEM-education;

- Monitoring results of using cloud services for the STEM-education support in a general school;

- Teaching students “Computational thinking” within the STEM, which is seen as the data processing with ICT in order to improve their analysis and synthesize the material presented by students to the project site;

- Raising the level of students’ knowledge about the STEM professions; motivating students to receive appropriate education for the STEM fields; developing STEM skills, promoting students’ critical thinking, etc.

There is worth noting the project «School on the Cloud» [12], funded with the support of the European Commission as the lifelong learning program. The project network will unite 57 partners, 18 European countries, 10 schools, 21 universities, companies, non-governmental organizations, national authorities, research centers, associations and adult education providers. Within the project, the cloud services are offered by companies Apple, Google, Microsoft, SAM Labs, etc.

The Cloud-based Simulations and Cloud-based Distributed Network Simulation Environment should be noted as the main the projects for students to carry out scientific research in the STEM fields. For examples, Google Maps, NetLogo, HubNet, etc.

According to the reviewed projects and studies, we can distinguish the main problems of using ICTs, in particular, cloud services, for the STEM-education support in a general school, and suggest possible solutions (Table 1).

Table 1. The main problems of using ICTs for the STEM-education support in a general school and possible solutions

Problems of using ICTs for the STEM-education support in a general school	Possible solutions of problems
Teachers unreadiness, unwillingness, and inability to use ICTs for STEM-education support in the classroom	Creating courses (MOOC) for teachers using ICTs for STEM-education support, and for cooperative learning and teaching activity [2, 7, 8, 12]
Providing policy and management for the STEM-education support	Creating ICTs centers for STEM-education support, that must coordinate national and international projects; select and offer ICTs for STEM-education support; organize national and international conferences, trainings, webinars, etc.; monitor the quality of the STEM-education and its impact [8, 11, 12]
Development of the virtual STEM-education environment	Engaging students, teachers, students of general schools and out-of-school educational institutions, students of higher educational institutions, scientists and researchers, etc. to develop the virtual STEM-education environment [2, 7, 8, 12]

Motivation of students to study the STEM disciplines	Promote “organizing fundraising events with the community or other projects that increase budgeting and develop math skills; teaching the youth sciences at summer camps or after-school programs; getting students to join the math and science clubs; encouraging technological hobbies among school children; helping them participate in science fairs; basic computing and internet browsing; including them in Internet forums and social networking; giving them books and magazines on science and mathematics; motivating them to pursue science and engineering careers; and helping them learn about computing, etc.” [13]

Thus, according to the projects described above and the highlighted issues, there has been found out that cloud services help teachers solve problems of the balance between the content of the curriculum and the practice, between the students’ attendance of classes and their interests, the rapid ICTs development and their effective use in educational process, etc.

Conclusions

The STEM-education is one of the most important fields for the development and education reforming**,** due to the high demand of the global labor market for specialists in the STEM industries.

The use of ICT, in particular cloud services, ensures effective implementation of the STEM-oriented approach in the general educational institutions at all levels of education.

The main problems that arise during this process:

- Creating formal and informal STEM online courses through ICT and involving students, teachers and professionals;
- Developing teachers’ information and communication competence in order to facilitate the continuous improvement of the STEM education environment through the use of ICTs, in particular cloud services;
- Selecting necessary ICTs for the educational process etc.

Solutions to these problems are:

- Organizing massive open online courses for teachers to acquire certain knowledge and develop their skills in ICT teaching, regardless of their qualifications, pedagogical experience, etc.
- Schools participation in educational projects, aimed at developing teachers’ skills and abilities to use ICTs, in particular cloud services, in their professional activities in accordance with the world priority areas in education.

Designing the cloud-based STEM-education environment at schools is the research perspective on the use of cloud computing technologies and STEM training in general educational institutions.

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